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(54) Heat Exchanger

A heat exchanger exhibits a pair of terminal boxes (301, 302) arranged parallel to each other, one of the terminal boxes (301) being arranged on the coolant intake side and the other terminal box (302) being arranged on the outlet side. A multitude of pipes (303) are connected to the terminal boxes (301, 302), ribs being arranged in the air passages between adjacent pipes (303). According to the invention, the terminal boxes (301, 302) are made as plastic extruded molded components, the terminal areas of the pipes (303) being embedded in a plastic sealing filler (318), by means of which a fluid-tight connection is produced between the terminal boxes (301, 302) and the pipes (303).

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Patent Claims

1. Heat exchanger with a pair of terminal boxes arranged parallel to each other, with one of the terminal boxes being arranged on the coolant intake side and the other terminal box being arranged on the outlet side. A multitude of pipes are connected to the terminal boxes via their terminal areas and ribs are provided in the air passages between adjacent pipes, **characterized that** the terminal boxes (**25, 125, 225; 301, 302; 341, 342; 401, 402**) are embodied as plastic extruded molded components, and that the terminal areas (**21*c*, 121*c*, 403*a***) of the pipes (**21, 121, 221, 303, 343, 403**) are embedded in a sealing filler (**30, 130, 230, 318, 411**), which surrounds the terminal areas (**21*c*, 121*c*, 403*a***) for the production of a fluid-tight connection.
2. Heat exchanger according to claim 1, characterized that the terminal boxes (**25, 125, 225; 301, 302; 341, 342; 401, 402**) consist of aluminum, or an aluminum alloy.
3. Heat exchanger according to claims 1 or 2, characterized that the sealing filler (**30, 130, 230, 318, 411**) consists of epoxy resin.
4. Heat exchanger with a pair of terminal boxes arranged parallel to each other, a multitude of pipes that are attached to the terminal boxes with their opposite terminal areas, and with ribs arranged in air passages between adjacent pipes, characterized that the terminal boxes (**25, 125, 225; 301, 302; 341, 342**) have axially extending separating plates (**25*d*, 125*d*, 225*d*; 306, 307; 346**), by means of which the interiors of the terminal boxes (**25, 125, 225; 301, 302; 341, 342**) are separated into a first chamber (**28, 128; 307, 308, 309**) and into a second chamber (**27, 127, 227; 310, 311; 340**). The first chamber (**28, 128; 307, 308, 309**) is provided for the passage of the coolant, and the second chamber (**27, 127, 227; 310, 311; 340**) is provided for the intake of a sealing filler (**30, 130, 230, 318**) for the purpose of attaching the pipes (**21, 121, 221, 303, 343**) contained therein to the terminal boxes (**25, 125, 225; 301, 302; 341, 342**).
5. Heat exchanger according to claim 4, characterized that the terminal boxes (**25, 125, 225; 301, 302, 341, 342**) consist of an extruded aluminum molded component.
6. Heat exchanger according to claims 4 or 5, characterized that the pipes (**21, 121, 221, 303, 343**) are embodied in a flat shape.
7. Heat exchanger according to one of the claims 4 to 6, characterized that the pipes have cylindrical terminal areas (**21*c*, 121*c*, 221*c***).
8. Heat exchanger according to claim 7, characterized that the terminal boxes (**25, 225**) have front walls (**125*c*, 225*c***) surrounding the cylindrical terminal areas (**21*c*, 221*c***) of the pipes (**21, 221**).
9. Heat exchanger according to one of the claims 4 to 8, characterized that the pipes (**121, 221, 303, 343**) have at least one recess (**141, 241, 319**) at their terminal areas (**121*c*, 221*c***) for preventing the slipping out from the terminal boxes (**125, 225; 301, 302; 341, 342**).
10. Heat exchanger according to one of the claims 4 to 9, characterized that the sealing filler (**30, 130, 230, 318**) consists of epoxy resin.

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11. Heat exchanger according to one of the claims 4 to 10, characterized that one side plate (**24**) each is arranged adjacent to the exterior pipes (**21**), with the side plates (**24**) being inserted into the second chamber (**27**) of the respective terminal box (**25**), and being attached there through the sealing filler (**30**) located within.
12. Heat exchanger according to claim 11, characterized that for improving the embedding within the sealing filler (**30**) the side plates (**24**) have holes (**24*e***) in those areas that each are provided for the second chamber (**27**) of the terminal boxes (**25**).
13. Heat exchanger according to claim 4, characterized that at least one of the terminal boxes (**302**) is axially separated into a first (**309*a***) and a second flow passage (**309*b***) by means of a separating plate (**315**), and that the interior chambers (**321*a***) of the pipes (**303**) are axially separated into a first (**321*a***) and second flow passage (**321*b***) by means of a separating plate (**322**), and that the first flow passages and second flow passages (**309*b*, 321*b***) are each connected to each other in the terminal box (**302**) and in the pipes (**303**) in such a way that two coolant passages are connected to each other via the other terminal box (**301**).
14. Heat exchanger according to claim 13, characterized that at least one separating plate (**325, 326, 327, 328**) is provided in each terminal box (**301, 302**) in the first flow passage for blocking and diverting the coolant flow so that the coolant flow has a zigzag shape.
15. Heat exchanger with a pair of terminal boxes arranged parallel to each other, with one of the terminal boxes being arranged on the coolant intake side and the other terminal box being arranged on the outlet side, and a multitude of pipes being connected to the terminal boxes via their terminal areas and ribs being provided in the air passages between adjacent pipes, characterized that
the terminal boxes (**401, 402**) are embodied as extruded aluminum molded components,
that the terminal boxes have separating plates (**401*a*, 402*a***) with a multitude of openings (**408**),
that the separating plates (**401*a*, 402*a***) separate the interior of the terminal boxes (**401, 402**) into a first chamber for the coolant flow, and into a second chamber (**416**) for the intake of a sealing filler (**411**) for the purpose of embedding the pipes (**403, 403*a***) inserted therein,
that the second chamber (**416**) is limited by flange partitions (**405, 407**) protruding from the separating plates (**401*a*, 402*a***),
that the pipes (**403**) have expanded and flattened terminal areas (**403*a***) in axial direction of the terminal boxes (**401, 402**),
that the expanded terminal areas (**403*a***) are aligned with regard to the openings (**408**) in such a way that the pipes (**403**) have an open connection to the first chamber if the pipes (**403**) are inserted between the protruding flange partitions (**406, 407**) of the second chamber (**416**), in which the expanded terminal areas (**403*a***) of the pipes (**403**) are embedded into the sealing filler (**411**) injected therein.

16. Heat exchanger according to claim 15, characterized that the expanded terminal areas (403a) of the pipes (403) have a rectangular cross section, the long sides of which extend in axial direction of the terminal boxes (401, 402).
17. Heat exchanger according to claims 15 or 16, characterized that the openings (408) in the separating plates (401a, 402a) are smaller than those of the cross section surface of the open terminals of the pipes (403).
18. Heat exchanger according to one of the claims 15 to 17, characterized that the flange partitions (406, 407) of the terminal boxes (401, 402) have ribs on their interior surfaces in order to prevent the slipping of the pipes (403).
19. Heat exchanger according to claim 18, characterized that the second chamber (416) of the terminal boxes (401, 402) each has air outlet grooves (412) extending lateral to the ribs (409), which allow for air to escape during the injection of the sealing filler (411).

Description

The invention relates to a heat exchanger, especially for the use as a radiator or condenser for automobiles, with a pair of terminal boxes arranged on opposite sides, with pipes being provided between them for the coolant flow through, between which corrugated rib elements are arranged. These types of heat exchangers are generally called Amulti-flow types.@ The term Aaluminum@ mentioned in the following description also includes aluminum alloys.

A typical example of a Amulti-flow type@ heat exchanger is a radiator for an automobile having a number of pipes that are arranged parallel to each other for the passage of the coolant, with their opposite terminals being connected to terminal boxes for the distribution and collection of the coolant. Air is fed between the pipes in order to produce a heat transfer.

The terminal boxes of the known heat exchangers consist of plastic molded components, with the pipes being connected to the terminal boxes via terminal box plates. Reference is made to figs. (24) and (25) for a better description of the known radiators. Reference number (101) denotes a terminal box that has a C-shaped cross section. The terminal box (101) has a rim (101a) protruding at its circumference. Flat pipes (102) are inserted into the openings (104) of a terminal box plate (103). Corrugated rib elements (106) are arranged between adjacent pipes (102). The terminal box plate (103) is equipped with tongue elements (108) at its circumference, and additionally with grooves (105) for the fitting of the terminal box (101).

The terminal box (101) and the pipes (102) are assembled into a radiator as follows. The pipes (102) and the rib elements (106) are alternately stacked next to or on top of each other in order to form a heat exchange area. The pipes (102) are then inserted into the openings (104) of the terminal box plate (103). After expanding the pipe terminals (102) they are connected to the terminal box plate (103) by means of welding or soldering. A seal or O-ring (107) is inserted into the groove (105).

The terminal box (101) is then fitted into the groove (105) until it makes contact with the seal (107). Finally, the tongue elements (108) are bent toward the interior until they make contact with the protruding rim (101a). This establishes a connection of the terminal box plate (103) to the terminal box (101).

The disadvantage of the radiator described above is that special components must be provided for the connection of the terminal box (101) to the pipes (102), namely the terminal box plate (103) and the seal (107). Furthermore, the pipe ends must be expanded and welded or soldered to the terminal box plate.

Accordingly, the production is extensive in cost. Furthermore, the terminal box (101) has a complicated shape so that an expensive mold is necessary for the production of the same. This also influences the production costs.

Another heat exchanger type is known for the use as a condenser in automobile radiators. This heat exchanger uses a gaseous coolant under high pressure, whereby a special flow pattern is provided in the heat exchange area. This is produced by a multitude of flat pipes that are arranged in a zigzag pattern, with rib elements being provided in the spaces.

This flow pattern creates a relatively large flow resistance. Larger pipe cross sections are provided in order to reduce the same. But the size of the heat exchange area is limited.

Furthermore, the efficiency of the heat exchanger across the heat exchange area is not consistent. It varies between the intake and outlet areas and also between the areas for the upflow and downflow of each pipe. This means that the heat exchanger is not distributed evenly across the entire heat exchange area.

It is necessary for the production of this heat exchanger that the pipes are bent into zigzag shapes, and that the rib elements are arranged in between. This must be done manually, because an automatic production is not possible. This also negatively influences the costs.

Some recommendations on adjusting heat exchangers of the Amulti-flow type@ for condensers of automobile radiator systems have been made. Opposing this, however, is the fact that such condensers must sustain high pressure. The connection of the terminal boxes and pipes cannot be sufficiently maintained for this purpose in the known heat exchangers of the Amulti-flow type.@

The invention is based on the task of providing a heat exchanger that is simple to produce and cost effective, provides an improved heat exchange, and is suitable for multiple applications.

This task is solved according to the invention in that each terminal box consists of a plastic extruded molded component, and that the terminal areas are connected to the terminal boxes by means of embedding them within sealing filler that has been injected around the same, which produces a fluid-tight connection.

Additional characteristics and advantages of the invention are evident from the additional sub- and alternative independent claims, as well as from the following description of the embodiment examples illustrated in the drawing.

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They show:

Fig. 1 a perspective view of a heat xchanger, assembled for the assembly into an automobile as a radiator;

Fig. 2 a perspective view of the connection between the terminal box and the pipes;

Fig. 3 a front view of the connection between the terminal box and pipes with a partial sectional illustration;

Fig. 4 a cross section along the level (4)-(4) in fig. 3;

Fig. 5 a cross section along the level (5)-(5) in fig. 3;

Fig. 6 a cross section along the level (6)-(6) in fig. 3;

Fig. 7 a cross section along the level (7)-(7) in fig. 3;

Fig. 8 a cross section across the connection between the terminal box and the pipes in another version;

Fig. 9 a cross section of the connection between the terminal box and the pipes in an additional version;

Fig. 10 a perspective view of a different heat exchanger with partial sectional illustrations for the use as a condenser in automobile radiators;

Fig. 11 a perspective view of the connection of the terminal boxes and the pipes of the heat exchanger according to fig. 10 in an exploded view;

Fig. 12 a cross section along the level (12)-(12) in fig. 10;

Fig. 13 an illustration of the flow pattern of the coolant in the heat exchanger according to fig. 10;

Fig. 14 a cross section across a modified version of a heat exchanger;

Fig. 15 a perspective view of an additional embodiment example of a heat exchanger for an automobile radiator;

Fig. 16 a perspective view of the connection between the terminal box and the pipes in the heat exchanger according to fig. 15 in an exploded view;

Fig. 17 a front view of the connection between the terminal box and the pipes in the heat exchanger according to fig. 15;

Fig. 18 a cross section along the level (18)-(18) in fig. 17;

Fig. 19 a cross section along the level (19)-(19) in fig. 17;

Fig. 20 a cross section along the level (20)-(20) in fig. 17;

Figs. 21A and 21B a schematic illustration of the process for expanding the pipe ends;

Figs. 22A and 22B a schematic illustration of a different process for expanding the pipe ends;

Figs. 23A and 23B a schematic illustration of a process for the injection with a sealing filler;

Fig. 24 a perspective view of a previously known heat exchanger, especially of the connection between the terminal box and the pipes in an exploded view, and

Fig. 25 a perspective view of the heat exchanger according to fig. 24 after completion.

The radiator illustrated in figs. (1) to (7) has a heat exchanger area (23) constructed of a multitude of pipes (21) and corrugated rib elements (22), which are arranged alternately to each other. Side plates (24) are arranged adjacent to the exterior rib elements (22) arranged opposite from each other, while the pipes (21) are connected to terminal boxes (25) at their opposite ends.

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The pipes (21) consist of aluminum, and are electrically seamed. Each pipe (21) has a flat or plate-shaped section (21*a*) in the center area, as well as expanded, cylindrical sections (21*c*) at the opposite ends with tapered sections (21*b*) that are arranged in between, as shown in figs. (2) and (3).

The terminal boxes (25) consist of an extruded aluminum cast in the shape of an elongated body as shown in fig. (2). The terminal boxes (25) have a special cross section, as is shown especially in fig. (6). According to it, three sides are created by common flat walls (25*a*) while the additional side is completely retracted and has a first bottom wall (25*b*) and a second bottom wall (25*d*). Reference number (25*c*) denotes a front wall that surrounds a hole (26) for receiving the pipe (21).

As further shown in fig. (6), the terminal box (25) is comprised of three chambers (26, 27, 28), with the chamber (27) being filled with a sealing filler, and the chamber (28) forming the main cross section for receiving the coolant. The first and second bottom walls (25*b*) or (25*c*) respectively, are equipped with openings (29), which are located at a distance to each other in relation to the distance between two adjacent pipes (21), with each opening (29) having a diameter, which essentially corr sponds that of the cylindrical section (21*c*) of the pipe (21). The pipe (21) is inserted into the opening (29) so far that its cylindrical section (21*c*) comes to rest flush with the second bottom wall (25*d*) so that the pipe (21) opens into the chamber (28). The sealing filler (30) is located in the chamber (27) in order to secure the pipe (21) within. This occurs for the purpose of ensuring that the cylindrical section (21*c*) of each pipe (21) is located between the first and the second bottom wall (25*b*) or (25*d*) respectively, and that the tapered section (21*b*) is fitted into the chamber (26).

The cylindrical section (21*c*) of the pipe (21) is embedded into the sealing filler (30) consisting of plastic. This sealing filler (30) is initially of liquid form, and is then injected through a suitable opening into the chamber (27). In the illustrated embodiment example, this occurs by means of a hole (32) constructed in a terminal plate (31), as shown in fig. 2.

The corrugated rib elements (22) are constructed into a corrugated shape by means of bending an aluminum plate, preferably with a grid being provided in each strip. The strip has a length that is slightly larger than the space between two adjacent pipes (21), with the total length of the rib element (22) essentially corresponding to the flat section (21*a*) of the pipe (21).

As fig. 3 shows, the rib elements (22) are each arranged between the flat sections (21*a*) of two adjacent pipes (21), with the exception of the opposite exterior rib elements (22), which are located between the flat sections (21*a*) and the respective side plates (24). The rib elements (22) are arranged between the respective adjacent pipes (21) in such a way that air flows through the rib elements (22) through the pipes (21) in a flow direction perpendicular to the coolant.

The letter (*P*) in Fig. 3 denotes an area into which the rib elements (22) do not protrude. This area is denoted as the rib-free area (*P*) in the following. This rib-free area (*P*) is enclosed by the front walls (25*c*) and the pipes (21) attached.

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in the terminal box (25), which prevents air from passing the heat exchange area (23) through this rib-free area without contributing to the intended heat exchange process. Any loss of air is avoided, which results in an improved effect of heat exchange. Another advantage is that the rib-free area (*P*) is covered by the front walls (25*c*) and by the pipes (21), thus maintaining a good appearance of the heat exchanger.

As fig, 3 further shows, the side plate (24) forms a box-shaped strut, which has a bottom section (24*a*) and side sections (24*b*) with bent edges (24*c*). The bottom section (24*a*) is comprised of tongue elements (24*d*) on both ends, whereby the tongue elements (24*d*) have a hole (24*e*). The tongue element (24*d*) is provided for the insertion into a slot (34), which is located in the terminal box (25). The side plate (24) also consists of aluminum. The tongue element (24*c*) is embedded into the sealing filler (30) and attached to the terminal box (25), with the hole (24*e*) being filled in by the sealing filler (30). This ensures the connection between the side plate (24) and the terminal box (25). If desired, two or more holes (24*e*) may be provided, whereby different shapes, such as round, rectangular, or triangular, are possible.

As seen in fig. 1, the terminal box (25) is equipped with a threaded eye (35) for the attachment of a temperature sensor for the recording of the coolant temperature. Additionally, the terminal boxes (25) have an intake pipe (36), an outlet pipe (37), a filling tube (38), and an attachment bracket (39). These are attached to the terminal boxes (25) before the pipes (21) and the terminal boxes (25) are connected to each other.

In order to connect the pipes (21) to the terminal boxes (25), the pipes are inserted into the openings (29). At the same time, the tongue elements (24*d*) are also inserted into the slots (34). Then the rib elements (22) are placed between respectively adjacent pipes (21), or between the

exterior pipes (21) and the side plates (24). Any clamping devices or attachment belts are n t necessary. Finally, the final connection of the components among each other is established by means of soldering or brazing. The assembly of the c mponents, however, is not limited to the above-described procedure.

Last the sealing filler (30) is injected into the chamber (27) of the terminal box (25) through the hole (32) in the terminal plate (31). The sealing filler (30) is initially of liquid form, but cures after the injection into the terminal box (25), if necessary, by means of heat. The sealing filler (30) ensures a liquid-tight connection between the pipes (21) and the terminal box (25) without requiring the known terminal box plates and O-rings.

Fig. 8 shows a modified terminal box (125), in which the first bottom wall (25*b*) of the above described embodiment example, has been omitted and replaced by a single bottom wall (125*d*). Accordingly, a chamber (127) is provided for the injection of sealing filler (130).

The pipe (121) is equipped with a thread (141) in its cylindrical section (121*c*) so that the sealing filler (130) can penetrate the thread (141), which achieves a firm connection

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between the pipes (121) and the terminal box (125). Instead of the helix-shaped thread, ring-shaped grooves, as illustrated in fig. 9, may also be provided. Several different types of recesses may also be provided instead of the thread (141), or instead of the grooves (241).

Fig. 9 shows an additional modified terminal box (225), in which a chamber (227) is provided for the injection of sealing filler (230). This chamber (227) is separated into two sections by means of a separating plate (225*d*). The sealing filler (230) has been injected into the two separated chambers (227) through holes (224) in the terminal box (225) and the separating plate (225*d*). The rib-free area is enclosed by the front walls (225*c*) and the pipes (221).

Fig. 10 to 12 illustrate an embodiment showing how the invention at hand can be used in a condenser for an automobile radiator. As fig. 11 shows best of all, an upper terminal box (301) and a lower terminal box (302) are provided. Both terminal boxes (301, 302) are connected to each other by means of pipes (303). Corrugated rib elements (304) are arranged between adjacent pipes (303) and between the exterior pipes (303) and side plates (305). The terminal boxes (301, 302) also consist of aluminum cast.

Each terminal box (301, 302) is equipped with separating plates (306, 307), which separate the interior spaces into filling spaces (310, 311) for the injection of sealing filler, and into coolant passages (308, 309) for feeding through of coolant. The filling chambers (310, 311) are located adjacent to the pipes (303). The upper terminal box (301) is closed by means of lids (312), while the lower terminal box (302) is equipped with an intake opening (313) and an outlet opening (314) so that coolant can be fed through the system. The coolant passage (309) in the lower terminal box (302) is separated into a front chamber (309*a*) and a rear chamber (309*b*) by means of a separating plate. The rear chamber (309*b*) is closed off by means of a protrusion (316) in the side plate (305) so that the incoming coolant can only enter into the front chamber (309*a*). It is closed off on the outlet side by means of a protrusion (316) of the other side plate (305).

The pipes (303) consisting of aluminum cast are attached to the terminal boxes (301, 302) with their opposite ends. They are inserted into slots (317), which are shaped into the exterior walls of the terminal boxes (301, 302) and into the separating plates (306, 307). In this way, the pipes (303) are open toward the coolant passages (308, 309). The inserted pipes (303) are embedded into the sealing filler (318), which is injected into the filling chambers (310, 311). Preferably, the pipes are equipped with recesses (319), such as grooves or rounded recesses in the terminal area so that they will receive more of the sealing filler (318) on their surfaces. The liquid sealing filler (318) is injected via holes (320) (fig. 10) into the exteri r walls f the terminal boxes (301, 302). The sealing filler (318) is preferably an epoxy resin.

The interior (321) of each pipe (303) is also separated into a fr nt chamber (and a rear chamber (321*b*)) via a central

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separating plate (322). This separating plate (322) forms an airtight contact with the separating plate (315) in the lower terminal box (302). This causes the two front chambers (309*a*) and (321*a*) to be connected to each other. Correspondingly, the same is true for the rear chambers (309*b*) and (321*b*) that are also connected.

As shown in fig. 10, the coolant passages (308, 309) in each of the two terminal boxes (301, 302) are equipped with locking plates (325, 326, or 327, 328). The locking plates (325, 326, or 327, 328) are arranged in the upper and the lower terminal box (301, 302) in such a way that they correspond to each other in relation to their positions. The semicircular locking plates (325, 327) are arranged in the upper terminal box (301) in such a way that they separate the coolant passage (308) into three equal sections. In the lower terminal box (302) the locking plate (326) blocks the front chamber (309*a*) of the coolant passage (309), and the locking plate (328) blocks the rear chamber (309*b*). Due to the locking plates (325, 236, 327, 328), the entire coolant passage (*C*) has a flow pattern as illustrated in fig. 13. The pipes (303) are separated into three groups I, II, and III. The coolant flows through these three groups of pipes (303) from the intake opening (313) to the outlet opening (314). In each of the groups the coolant is forced to flow through a front and through a rear passage.

The locking plates (325, 326, 327, 328) are inserted into slots (329), which are formed into the respective terminal boxes (301, 302). The locking plates (325, 326, 327, 328) have attachment brackets (330, 331, 332, 333), the ends of which are bent and equipped with attachment holes (334), which are intended to attach the heat exchanger within a system, such as in an automobile.

The rib elements (304) are soldered, or brazed onto the pipes (303) and to the side plates (305).

The side plates (305) have bottom and side walls, which extend from both edges, whereby the bottom has a top protrusion (305*a*), and a bottom protrusion (305*b*), which are intended to be inserted into slots (335) in the respective terminal boxes (301, 302). The protrusions (305*a*, 305*b*) are soldered or brazed to the same.

Fig. 14 shows additional modified terminal boxes (341, 342), which have flat sides that are directed toward the pipes (343). An upper separating plate (346) and a lower separating plate (347) are arranged in the upper terminal box (341). Adjacent to the pipes (343) are filling chambers (340), which are separated into two sections by means of the lower separating plate (347), and into which the sealing filler (318) is injected independently of each other in order to secure the pipes (343) inserted into the same. The other components are the same as shown in figs. 10 and 11, and which are characterized by the corresponding reference numbers.

Figs. 15 to 20 show another embodiment example of the invention. The general construction is the same as in the previously described embodiment examples. A pair of terminal boxes (401, 402) are provided, which are connected to each other by means of pipes (403). Corrugated rib elements (405) are arranged between adjacent pipes (403) and between the exterior pipes (403) and the respective adjacent side plates (404). The terminal boxes (401, 402) as well as the pipes (403) consist of aluminum cast.

Each of the terminal boxes (401, 402) has an interior that

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is separated by separating plates (401*a*, 402*a*). The respective interior section is intended for the passage of the coolant, while the respective exterior section (416) is intended to serve for receiving the pipes (403). The

exterior section (416) is enclosed at its top and bottom by flange partitions (406, 407). The separating plates (401*a*, 402*a*) are equipped with openings (408) located at suitable intervals. The flange partitions (406, 407) have ribs (409) on their interior surfaces, which cause the pipes (403) in the exterior sections (416) to be retained securely. The coolant passage in each pipe (403) is separated by a separating plate (410) into a partial passage located above and a partial passage located below. As fig. 16 shows, the terminal areas of the pipes (403) are flattened, or are laterally enlarged in an expanded terminal area (403*a*).

Figs. 21 and 22 show the process for spreading apart the terminal areas (403*a*) of the pipes (403). In fig. 21A the material of the pipes 403), which extends along the edges of the separating plate (410), is slashed open by means of the formation of tongue members (410*b*), which are then spread toward the exterior, as shown in fig. 21B. As an alternative, the separating plate (410) is torn apart into tongue members (410*a*) by means of a cutting machine. This is shown in fig. 22A. Fig. 22B illustrates how the tongue members (410*a*) are spread apart. The size and shape of the expanded terminal areas (403*a*) of the pipes (403) are constructed in such a way that they fit airtight into the exterior sections (416).

The pipes (403) are inserted into the exterior sections (416) of the terminal boxes (401, 402) in such a way that the open end of each pipe (403) is located opposite an opening (408), and therefore has access to the coolant passage. However, it is not always necessary that the open ends of the pipes (403) come to rest completely centric to the openings (408). The latter are in fact slightly smaller than the diameter of the expanded terminal areas (403*a*) of the pipes (403).

Sealing filler (411), such as epoxy resin, is injected into the exterior sections (416). By means of curing, it ensures the secure connection between the terminal boxes (401, 402) and the pipes (403). The process of injection of the sealing filler (411) is illustrated in fig. 23. At first the liquid plastic is injected through a slot between the adjacent pipes (403), with the terminal boxes (401, 402) being turned in such a way that the exterior sections (416) are open at the top. As shown in fig. 23B, the liquid plastic expands across the entire exterior section (416). In this way, the air is replaced by the expanding plastic. The softer the manner in which this replacement takes place, the quicker the plastic will expand. For this purpose, air outlet grooves (412) are provided, which extend lateral to the ribs (409) fig. 16.

The corrugated rib elements (405), which are preferably equipped with a pattern, have a height that is almost as high as the distance between two adjacent pipes (403). The rib elements (405) are arranged between adjacent pipes (403) and between the respective exterior pipe (403) and a side plate (404). Their connection is established by means of soldering or brazing. As shown in fig. 16, the rib elements (405) do not extend across the expanded terminal areas (403*a*) of the pipes (403). The terminal boxes (401, 402) are closed by means of lids (413), and have an intake (414) and

an outlet (415) for the intake and outlet of the coolant.

The assembly of the previously mentioned components is performed as follows. The pipes (403) and the rib elements (405) are arranged alternately to each other. The terminal boxes (401, 402) are attached to the expanded terminal areas (403*a*) of the pipes (403) so that these terminal areas (403*a*) can be inserted into the exterior sections (416). The ribs (409) effectively prevent the pipes (403) from slipping out from the respective exterior section (416). The rib elements (405) and the pipes (403) are then soldered to each other. Finally, sealing filler (411) is injected so that the expanded terminal areas (403*a*) are embedded within.

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[see source for figs. 1 and 2]

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[see source for figs. 3 to 5]

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[see source for figs. 6 to 9]

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[see source for fig. 10]

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[see source for fig. 11]

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[see source for figs. 12 to 14]

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[see source for figs. 15 and 16]

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[see source for figs. 17 to 20]

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[see source for figs. 21 to 23]

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[see source for figs. 24 and 25]